Air University

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# "Is Tube Artillery a Viable Fire Support Platform for the United States Military on the Battlefields of the Future?"

By

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# DISCLAIMER

## Biography

Supervisory Special Agent Michael Craig Harris entered the Federal Bureau of Investigation (FBI) in 1996. After graduation from the FBI Academy, Special Agent (SA) Harris was assigned to the FBI Houston Division where he investigated White Collar Crime matters. In 1999, SA Harris was transferred to the Los Angeles Division and was assigned to the Southern California Drug Task Force where he conducted drug trafficking and criminal enterprise investigations. While assigned to the Los Angeles Division, SA Harris participated in two Temporary Duty Assignments (TDY) to Iraq and one TDY to Joint Task Force Guantanamo Bay. In 2009 SA Harris was promoted to Supervisory Special Agent (SSA) and was transferred to FBIHQ to work as a Program Manager in the Criminal Investigation Division, Drug Unit. In 2012, SSA Harris was promoted and detailed to the Department of Justice's Organized Crime Drug Enforcement Task Force Executive Office where he served as an Associate Director in charge of the Consolidated Priority Organization Target Program. In December 2013, SSA Harris reported to the Legal Attaché Office at the U.S. Embassy in Kabul, Afghanistan where he served as an Assistant Legal Attaché in charge of the General Investigations Program. In January 2015, SSA Harris was assigned to the International Operations Division, Middle East Unit at FBIHQ. Prior to joining the FBI, SSA Harris served as an Artillery Officer in the United States Marine Corps. SSA Harris is currently a student at the Air War College at Maxwell Air Force Base, Alabama.

**Abstract**: Historically, tube artillery has been the primary fire support platform in the United States military due to its all-weather responsiveness, superior ability to mass fires and suppress targets, and the devastating effects it has on enemy forces making it the biggest killer on the battlefield. However, the evolution of weaponry technology and the advent of precision guided munitions (PGMs), multiple launch rocket systems, and unmanned aerial vehicles has served to diminish and undervalue tube artillery in the United States military present day. This treatise will examine the use of PGMs, the evolution of howitzer employment, and the marginalization of the field artillery branch in recent conflicts relative to other fire support weapon systems and assess how in order to remain a vital, cost-effective, fire support platform, tube artillery must continue to improve its mobility, range, and accuracy, and ultimately earn the confidence of maneuver element commanders to employ it when troops are in contact and lives are on the line.

## Introduction

Throughout the history of modern warfare, tube artillery has been the combat arm that has consistently provided the most responsive fire support to maneuver elements with devastating effects making it the biggest killer on the battlefield. In the United States military, tube artillery has been used to great effect in a variety of conflicts since World War II including the Korean, Vietnam, and Persian Gulf Wars. However, as the nature of warfare and weaponry technology has transformed with the advent of precision guided munitions (PGMs), multiple launch rocket systems, and unmanned aerial vehicles, tube artillery in the United States military has been undervalued. This treatise will examine the use of PGMs, the evolution of howitzer employment, and the marginalization of the field artillery branch in recent conflicts relative to other fire support weapon systems. In order to remain a vital, cost-effective, fire support platform for the United States Military, tube artillery must continue to improve its mobility, range, and accuracy, and ultimately earn the confidence of maneuver element commanders to employ it when troops are in contact and lives are on the line.

## Brief History of Artillery in the in the United States military from WWII to present

The United States has achieved advances in artillery technology dating back to World War II when, thanks to improved fire direction, spotting techniques and employment tactics, American artillery was particularly feared by the German Army.[1] Although the United States Armed Forces entered the Korean and Vietnam wars with essentially the same field pieces that were used in World War II, the U.S improved artillery mobility with the advent of transporting howitzers via fixed wing and rotary air assets.[2] The

Vietnam War saw further developments in employment tactics, based upon the nature of the counterinsurgency fighting, as artillery batteries were frequently positioned at firebases and often fired missions in close support of friendly troops which demanded improved accuracy to reduce the chances of friendly casualties.[3]

By the advent of the Persian Gulf War in 1990, American artillery had significantly improved its ordnance and employment. Of particular note was the effectiveness of the dual-purpose, improved conventional munitions rounds (DPICM) which were detonated in an airburst at an optimum altitude to rain sub-munitions down on armored or personnel targets. These DPICM rounds were particularly effective against Iraqi mechanized infantry and armor and were referred to as "steel rain."[4] In addition, in reminiscence of Napoleon's aggressive manner of employing his artillery during his campaigns in Europe, the Army and Marine Corps conducted combined arms raids along the Kuwait-Iraqi border using artillery batteries displaced to firing positions close to the border, light armored infantry vehicles, and air assets to locate, fix, and destroy Iraqi artillery and infantry in quick night-time strikes.[5] The Persian Gulf War also saw a historic first war-time use of an artillery laid minefield when a Marine Corps Artillery Battalion laid a FASCAM (field artillery family of scatterable mines) minefield emplaced in combat during the Battle of Khafji.[6] Additionally, this conflict witnessed the introduction of Multiple Launch Rocket Systems (MLRS) and an early version of PGMs in the M712 Copperhead artillery round being used in combat for the first time.

## Improved Artillery Technology since the Persian Gulf War

The time period since the Persian Gulf War has seen significant technological advances in both land and air based weapon systems and munitions with many of these developments positively impacting the requirements for accurate artillery fire. Dating back to the time of World War I and as taught at the United States Army Fires Center of Excellence and Field Artillery School, the five requirements for accurate (artillery) fire are: accurate target location and size, accurate firing unit location, accurate weapon and ammunition information, accurate meteorological information, and accurate computational procedures. [7] Of particular note is the deployment of GPS technology which, coupled with PGMs, has substantially reduced the margin for error of target and firing unit location which, in turn, has reduced the number of adjusting rounds needed to walk effects onto target. This advancement is significant for tube artillery as the greatest casualties come from first round effects on target when enemy forces are caught unaware and have not had time to disperse or take shelter.[8] While GPS and PGM technology were utilized to great effect during Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF), the nature of these conflicts and the manner that the U.S. Military used tube artillery has caused some to question its viability as a primary fire support platform for ground combat forces in the future.

## Artillery in Operation Iraqi Freedom

Operation Iraqi Freedom saw a major change in the use of tube artillery. The invasion of Iraq, in March 2003, witnessed the amassing and employment of a large, conventional American land force composed of armor, mechanized infantry, artillery and necessary

logistics support, though this composition was distinguished by the lowest ratio of artillery to maneuver units since the Spanish-American War.[9] During the initial advance to Baghdad, artillery was used in its traditional missions of direct support, reinforcing, general support, and general support reinforcing to maneuver units. However, as the war transitioned from a large-scale mechanized land battle to a counter-insurgency fight, the role of artillery changed as well. The relatively expeditious defeat of the Iraqi military negated the need for mass artillery fires as the fire support requirements changed to missions such as Harassing and Interdiction (H&I) fires as used by the U.S. Army 4th Infantry Division at Tikrit in "proactive counterfire" missions to suppress enemy mortar and rocket locations.[10] However, improved developments in artillery range and accuracy, significantly influenced by the introduction of PGMs and Multiple Launch Rocket Systems (MLRS) in theatre, contributed to the ability to effectively employ fires in counterinsurgent engagements while minimizing collateral damage. As the fighting in Iraq progressed, artillery was used selectively with differing degrees of effectiveness in missions such as terrain denial-counter-fire though in some instances it was brought to bear in a more traditional role. An example of this being during the second battle for Fallujah in 2004, when Marine Artillery fired more than 4000 shells in support of operations to retake the city.[11] Other instances involving the effective use of PGMs by tube artillery include missions shot by the Colorado National Guard, 169th Fires Brigade, whose commanding officer Kenneth Lull reported firing "17 Excalibur rounds for the 3-2 SBCT when it cleared Baqubah of insurgents in intense combat during Operation Arrowhead Ripper. In one mission, we fired Excalibur on a known enemy safe house. Although it did not level the building, it killed everyone in the building without harming

children who were playing outside in front of the house next door about 30 yards away." [12] The potency of artillery PGM in OIF was noted by then LTG Raymond T. Odierno, commander, Multinational Corps-Iraq (MNC- I), who stated that 155mm Excalibur and guided multiple-launch rocket system (GMLRS) unitary PGMs, "...were extremely effective. In fact, GMLRS and Excalibur were my brigade commanders' weapons of choice." [13]

## Marginalization of Artillery

As the war in Iraq transformed from a high intensity conflict to a counterinsurgency, concerns about collateral damage led the U.S. military to employ tube artillery less. Subsequently, artillery units were being utilized in other mission essential roles such as provisional infantry, civil affairs, and security missions.[14] Artillery units were seen as an appealing option for these missions since they had the basic combat skills and weapons proficiency as well as an ample organic inventory of vehicles and communications equipment.[15] Artillery units were further tasked with providing training to Iraqi Security Force (ISF) units and advising on combat operations.[16] While there are valid concerns about collateral damage, antiquated notions of the gross inaccuracy of artillery fire seemed to contribute to the restrictions and relative limited of use of artillery throughout OIF. However, while close air support (CAS) continued to be an important fire support asset for maneuver units, the dependability and responsiveness of artillery ensured that it was not ever completely transitioned into non-traditional security roles though its role as the primary fire support element for maneuver units began to noticeably diminish.[17] The introduction of the Excaliber PGM in 2008 served, to some degree, to mitigate concerns about collateral damage from artillery fire. After overcoming some initial coordination

issues regarding authorization to fire it, the Excaliber PGM was used with great effect to support troops in contact during various engagements.[18]

While the wars in Iraq and Afghanistan progressed, the continued deployment and utilization of artillery soldiers and Marines outside of their traditional cannoneer and fire support duties slowly began to erode the core competency of artillery units to effectively perform their mission. In 2010, The U.S. Army National Training Center & Joint Readiness Training Center reported that over 90% of Field Artillery military occupational specialty (MOS) soldiers were deploying outside of their traditional skill set. This atrophy in artillery related skills eventually translated into maneuver commanders losing confidence in artillery support.[19] This high degree of concern led three former U.S. Army Brigade commanders to draft a white paper in 2010 titled *The King and I: The Impending Crisis in the Field Artillery's Ability to Provide Fire Support to Maneuver Commanders.* They cited the "lack of modularity…lack of training," and how maneuver commanders were now responsible for training fire support personnel.[20] Furthermore, the loss of core competency by field artillerymen became such a concern that General McCrystal, Commander of the International Security Assistance Force in Afghanistan, issued a memorandum outlining the need for increased fire support training, among his other directives.[21]

## Other Fire Support Assets in U.S. inventory: Multiple Launch Rocket Systems

The lessening role of tube artillery can be attributed, to some degree, to the advent and evolution of alternative fire support platforms, as well as improved technology for existing platforms. A comparative review of these platforms starts with the Multiple

Launch Rocket System (MLRS) which, in some variation, have been used by the United States military dating back to World War II. The current M270 version and its variants, adopted by the U.S. Army in 1983, saw their first combat action in the Persian Gulf War in 1991.[22] The premise of this weapon system is a rocket launching system mounted on a track or vehicle chasis, capable of shooting multiple rockets simultaneously with precision accuracy in a fire support role. Unlike the accuracy of the traditional free-flight MLRS rocket that degrades as the range to the target increased, guided rockets, which are the primary munitions currently employed, use a GPS aided navigation system which provides consistent, improved accuracy from a minimum range of 15 kilometers to a maximum of 60 to 70 kilometers to attack area and point targets.[23] Designed for and proven to be very effective in high intensity conflicts, the M270A1 launcher has not been able to support light infantry and air assault missions nor had the ability to deploy in forced entry environments.[24] Accordingly, a variant identified as the M142 High Mobility Artillery Rocket System (HIMARS) launcher on a wheeled platform was developed and fielded providing the Army and Marine Corps with a critical precision deep fires capability better suited for light and early entry forces.

In a comparison of capabilities, there are some significant advantages that MLRS and HIMARS possess over tube artillery and other fire support platforms. For example, the ability to mass fires for first round effects is easily accomplished with several launchers which each can fire six precision guided rockets simultaneously allowing for a higher concentration of fire from fewer weapons platforms than is possible with tube artillery. Additionally, MLRS launchers have the capability to rapidly displace after conducting fire missions thereby minimizing the risks posed by counter-battery fire or enemy air

attacks. A critical advantage that MLRS has over tube artillery is the range of its target fan; depending on the type of munitions, MLRS rockets can range out to 82 kilometers while it can also shoot tactical missiles out to 150 km; substantially more target range than tube artillery which currently maxes out at 30 kilometers with rocket assisted projectiles (RAP) and 40 km with PGMs.[25] While MLRS brings with it the significant capabilities to provide precision mass fires as well as substantially outrange foreign and friendly tube artillery, this weapons platform does have some inherent shortcomings relative to other ground based fire support weapons platforms. With MLRS designed as either a tracked or wheeled (HIMARS) weapons platform, certain types of terrain limits the ability of the MLRS or HIMARS systems to traverse or deploy. Additionally, the weight of MLRS rockets limits the transport quantity of its mobile combat load as well as its ammunition re-supply. For example, MLRS rocket munitions M26 227 mm high explosive fragmentary (HE FRAG) rounds weigh 675 pounds and are transported in Heavy Expanded Mobility Truck M985 (HEMT) and a Heavy Expanded Mobility Trailer (HEMAT) M989.[26] Each can carry four launch pod containers for a total of 48 rockets in a HEMT/HEMAT load.[27] Each launch pod container weighs 5200 pounds.[28] If an aerial resupply is sought and is tactically possible, a CH-47 helicopter can carry 24,000 pounds internally which amounts to only four launch pods.[29] When compared to the 98 pound weight for a 155 mm tube artillery shell, this weight differential significantly limits the mobile combat load and the ability of MLRS to carry on sustained firing operations when removed from resupply hubs. In addition to the weight of the ammunition, the size and weight of the weapons platforms themselves causes deployment limitations. The HIMARS system weighs 24,000 pounds while the MLRS weighs

approximately 52,990 pounds.[30] Because of its size, the MLRS can only be transported by heavy transport aircraft such as C-141, C-5, and C-17 while the HIMARs is transportable via C-130 aircraft.

## Unmanned Aerial Vehicles (UAVs)

A fire support platform that has brought deep strike capability above and beyond any ground based weapon system is the Unmanned Aerial Vehicle (UAV). Though UAVs have been used by the United States military since the Vietnam War, their use as an offensive weapons platforms came to prominence in the war against terrorism starting in 2002. [31] While the first UAV to be utilized in an offensive strike capacity was the MQ-1 Predator, the first UAV to be used in a true "hunter-killer" role in Iraq and Afghanistan is the MQ-9 Reaper.[32] The Reaper is capable of carrying AGM-114 Hellfire missiles, GBU-12 Paveway Laser Guided Bombs, and GBU-38 JDAM bombs.[33] With a fully armed Reaper loaded with 1000 pounds of ordnance having an endurance time of 14 hours, and up to 42 hours with external fuel tanks, UAVs provide the United States military with a weapons platform that can surgically strike both high value and conventional targets no matter where they are located.[34] The advantages of utilizing UAVs as a fire support platform are numerous; perhaps none being bigger than the benefit of carrying out offensive strike capabilities without posing any direct risks to U.S. personnel operating the equipment. Additionally, the ability to carry a heavy payload of PGMs allowing UAVs to surgically strike designated objectives while minimizing collateral damage makes it the preferred weapons platform for high-value target missions. Furthermore, the surveillance capabilities of UAVs allow for real-time battle damage assessment, intelligence collection, and identification of potential follow-on targets.

Additionally, the enhanced loiter time of UAVs increases the targeting window and allows for both rapid response target engagement or sufficient time for target development or analysis. Lastly, the relatively small profile of UAVs makes them less likely than manned fixed wing or rotary aircraft to be detected and face ground fire or counter measures.

For all of the notable advantages that UAVs offer as a fire support platform relative to other weapons systems, there are also some vulnerabilities that must be taken into consideration. As demonstrated by platform losses in Libya and Iran, UAVs are vulnerable to sophisticated air defense systems. [35] Specifically, UAVs are vulnerable to radars, manned aircraft, anti-air missiles and anti-aircraft artillery, electronic jamming, hacking, and spoofing. [36] As the UAV platforms stand currently, survivability in high threat environments will require modifications in techniques, tactics and procedures, as well as system upgrades and improvements such as stealth capabilities to avoid radar detection, greater speed, and jammers. [37]



## Manned Aircraft

While artillery has served as the primary fire support platform for U.S. ground forces and maneuver elements since the days of the Continental Army, the employment of fixed and rotary wing aircraft in a close air support (CAS) role has served as a vital and complementary fire support element from World War II through the present date. The capabilities that air assets bring to the fight are lethal and varied with guns, bombs, rockets and missiles being among the ordnance that can be brought to bear. Effective utilization of CAS requires detailed integration and coordination by ground forces so as to ensure the safety of friendly troops as well as proper target identification and

engagement. This coordination for the U.S. military is conducted by Joint Terminal Attack Controllers (JTAC) and Forward Air Controllers (FAC) attached to ground troops and maneuver elements.[38] There are a number of distinct advantages that CAS platforms have over ground based fire support assets; notably the ability to strike targets at ranges far greater than can be engaged with ground fire support. Additionally, CAS has the ability to identify and strike targets that may be concealed or in defilade and not identified by ground forces. Furthermore, air platforms, such as the A-10 Thunderbolt, are traditionally more effective against certain types of targets such as enemy armor and mechanized infantry. The variety of air platforms offers a multitude of weaponry and ordnance that can be selectively utilized depending on the type of engagement. For example, if a friendly position is in danger of being overrun, an AC-130 gunship, with its arsenal of weaponry, can circle the area engaging enemy targets until the momentum of the attack is broken.

For all of the devastating effects that CAS brings to the fight, air assets have a number of vulnerabilities that limit its ability to be an all-encompassing fire support platform. The great equalizer that will always limit CAS's ability to be brought to bear is weather; poor meteorological conditions can delay or eliminate altogether the ability of air assets to participate in combat operations. This limiting factor is obviously a critical shortcoming should fire support be needed when the weather is bad. Another potentially significant vulnerability of air power is the threat posed to it by integrated air defenses (IAD). In low intensity conflicts such as the wars in Iraq and Afghanistan, this threat varies and is not always a limiting factor. However, when facing a foe such as Russia, China or Iran with technologically advanced air defenses, IAD becomes a real problem.

Surface-to-air missiles (SAMs), anti-aircraft artillery, and heavy machine gun fire all pose very serious threats to CAS assets. Additionally, opposing forces that have sophisticated air defenses will often have their own air interdiction aircraft that can pose a threat to air assets. Another challenge involved when using CAS is the potential difficulties that air assets can have with distinguishing between friendly and enemy forces. Though doctrine dictates that terminal control of CAS be directed by a JTAC or FAC, the confusing and fluid nature of ground combat actions can make accurate targeting of ordnance challenging.

## Current Capabilities of U.S. Tube Artillery

Tube artillery's devastating effects on enemy troops and it's ability to shape the battlefield has provided for the artillery branch's traditional role as a sizeable component of the United States military's ground combat forces in the both the Army and Marine Corps. However, restructuring of the U.S Armed Forces has resulted in a downsizing of artillery assets. Currently the Army has 100 battalions of tube artillery in the active duty, reserve and national guard components, while the Marine Corps has 21 artillery batteries organized into seven battalions; this staffing represents a 50% reduction of the artillery assets the U.S. military had in 1985.[39]

The reduction in artillery battalions has been a reflection of the decreasing size of the Army and has also been in accordance with the Army and Marine Corps' transformation to a lighter, leaner force; moving away from being oriented for fighting large scale air-land battles to being postured towards more effective engagement in low intensity conflicts. Currently the U.S. military has three howitzers in the inventory that are

actively being employed: M119A3 105 mm towed howitzer (includes M119A2 variant), M777 155 mm towed howitzer, and the M109A6 Paladin self-propelled 155 mm howitzer. The Army fields all of these howitzers plus the latest self-propelled variant, the M109A7 which is scheduled to go into full production in 2017, while the Marine Corps only employs the M777.[40] The M119A2/A3 as a lighter, more mobile field piece is deployed with airborne and light infantry units and can be transported via sling load under a UH-60 or CH-47 or air dropped in airborne operations.[41] The primary howitzers of the U.S. military presently, however, are the M109A6 and M777. The ammunition and powder utilized by these two weapons platforms is standardized and features a variety of shell/fuze combinations including: high explosive (point detonation/air burst), smoke, white phosphorous, illumination, area denial munitions, rocket assisted projectiles, and improved conventional munitions. All of the aforementioned munitions are not precision guided and are fired using conventional fire direction control methods. Both weapon systems have a .39 caliber gun tube which provides for a range of 24 km for HE and other conventional rounds and 30 km for rocket assisted projectiles, while precision guided munitions can range out to 40 km. [42] The towed and self-propelled platforms each afford certain advantages and disadvantages. The M109A6's armored cab affords crew protection from shrapnel and small arms fire while also providing for internal ammunition storage of thirty-nine 155 mm shells. [43] Additionally, an internal navigation system and sensors to detect where the howitzer is laid allows the M109A6 to stop, load, and fire within 30 seconds with the same accuracy as howitzers that require being emplaced and laid on a target azimuth.[44] The Paladin has the further advantage of quick displacement to avoid counterbattery fire or air strikes and tactical maneuverability

to being able to keep up with armored and mechanized infantry formations. The primary advantage afforded by the M777 towed howitzer, relative to the Paladin, is its lighter weight which enhances its air mobility via rotary or fixed wing aircraft for employment in firing positions that could not be accessed by a self-propelled howitzer. Additionally, maintenance upkeep on towed howitzers is typically much more manageable relative to the work required to keep the tracks and engines running on self-propelled howitzers.

## Technological advances for tube artillery

Artillery in the U.S. military has traditionally been employed as an area fire weapon that relied upon massed fires to have effects on target, whether it be formations of infantry or armor, or hardened targets. However, recent technological advances have dramatically improved artillery's ability to have first round target effects which historically has resulted in the most casualties. Notably, the profusion of ground position sensor (GPS) technology has dramatically reduced the mean point of impact error conventionally calculated into artillery fire direction computations with the ability to accurately locate target and gun locations, two of five the requirements for accurate artillery fire as set forth by the U.S. Field Artillery School.[45] As technological advances have taken hold across the spectrum of weaponry and ordnance, the development of PGMs has significantly impacted how artillery can be employed on the battlefield. The M982 Excalibur PGM is a GPS guided shell with a range of approximately 40 meters with a circular error probable (CEP) of 5-20 meters.[46] When compared to the CEP of a conventional unguided artillery shell which stands at 267 meters, the precision of the Excalibur round enhances the capability to safely fire artillery in the close vicinity of

friendly troops or non-combatants.[47] Tests have shown that one Excalibur shell can accurately hit an intended target that would typically take 10 to 50 non-guided artillery shells. [48] The effectiveness of this shell was demonstrated in June 2012 in Helmund Province, Afghanistan, when Battery G, 2nd Battalion 11th Marines dropped an Excalibur round on insurgents 36 km away marking the longest operational shot in the history of the M777 howitzer.[49]

Another technological development that has positively impacted artillery fires and employment is the M1156 Precision Guided Kit (PGK) smart fuze that can be fired on M795 high explosive or M549 rocket assisted projectiles. The PGK serves to make conventional artillery shells into smart weapons with the capability of impacting within 50 meters of the target at any range.[50] While not having the degree of accuracy or range of the Excalibur shell, the PGK does provide precision-guided munitions capability at a fraction of the cost.

Advances in fire direction technology for both the Paladin and M777, to include self-contained digital fire control and inertial navigation systems, have substantially diminished the time required to occupy a firing position, initiate fire missions, then displace. These developments have significantly impacted the survivability of artillery on the battlefield as this window is when artillery batteries are the most vulnerable to detection and attack.[51]

All of these technological advances have been critical to ongoing efforts to sustain artillery's viability as the "go to" fire support element for maneuver forces and attaining increased levels of precision remains a key priority for senior military planners and the artillery community. However, the ability to acquire and employ this technology at costs

that are manageable given current budget constraints is a key consideration that must be taken into account for future strategic planning. Incorporating technological advancements for artillery and other weapons platforms while trying to control their costs remains one of the biggest challenges that the Department of Defense faces going forward.[52]

## Viability of Cannon Artillery in the future relative to other Weapons Systems

Although there have been dramatic technological improvements in the ordnance precision and deep strike capability of these alternate platforms, tube artillery should remain as the primary fire support element for the United States military due to its mobility, ordnance variety, ability to mass fires, all-weather availability, and perhaps most important, it's relative cost effectiveness.

**TABLE 1: FIRE SUPPORT PLATFORM COST COMPARISION**

| **Weapon System** | **Per Unit Cost** | **Flight Hour Cost** |
|---|---|---|
| M777 155 mm howitzer | $2,500,000[53] | N/A |
| M109A7 155 mm howitzer | $10,300,000[54] | N/A |
| M270 MLRS | $2,300,000[55] | N/A |
| M142 HIMARS | $2,950,000[56] | N/A |
| AH-64E Apache | $35,500,000[57] | $3581[58] |
| AH-1Z Viper | $29,890,000[59] | $1757[60] |
| A-10 Thunderbolt | $18,800,000[61] | $17,716[62] |
| AC-130U Spectre Gunship | $210,000,000[63] | $45,986[64] |

| | | |
|---|---|---|
| F/A-18 E/F Super Hornet | $60,900,000[65] | $10,507[66] |
| F-15E Eagle | $29,900,000[67] | $42,200[68] |
| MQ-1B Predator | $5,000,000[69] | $3769[70] |
| MQ-9A Raptor | $16,050,000[71] | $4762[72] |

The rapid ascent of PGM technology and improved weapons system capabilities has seen a corresponding increase in production and operating costs of fire support weapons platforms in the inventory of the United States military. As set forth in Table 1, from a purely cost per unit perspective, there is a not a significant cost divergence between M777 and the M270 and M142 rocket launcher systems while the M109A7 Paladin comes with a substantially higher price tag though this does also include an ammunition carrier as the howitzer and carrier are sold as a set. Though not quantified numerically, the M777 has a lower maintenance and upkeep relative to the other weapon systems that have self-contained propulsion systems.

When compared to manned rotary and fixed wing aircraft utilized in the CAS role, tube artillery presents a massive savings. For example, the per unit cost level of howitzers ranges from .5% to 6% of that of each aircraft. Furthermore, the added expense of cost per flight hour, which for fixed wing platforms, can become substantial ranging up to over $45,000 for the AC-130. It is evident, from the per unit cost analysis that the deep strike and precision guided targeting capabilities afforded by manned air assets comes at a significant cost upgrade relative to ground platforms. Additionally, the substantial cost per unit of manned aircraft translates into fewer being produced which, as older airframes are retired, ultimately results

in a smaller composite force available to provide CAS support. Similar to manned air assets, a review of the unit costs of UAVs shows significant cost differential to ground fire support platforms with howitzers costing from 16% to 64% of that of UAVs on a per unit basis. UAVs afford many of the capabilities of manned air assets but at a lower unit and hourly flight cost and without any risk to a pilot.

Another point of comparison is the relative cost of ordnance. As effective and deadly as PGMs are, their price tag is substantial relative to conventional ordnance as seen in Table 2.

**TABLE 2: COST OF ORDNANCE**

| **Ordnance Type** | **Cost per unit** |
|---|---|
| M795 155 mm HE shell | $1600[73] |
| M982 Excaliber 155 mm PGM | $68,000[74] |
| M1156 PG Fuze Kit | < $3000[75] |
| M31 Guided MLRS Rocket | $133,000[76] |
| GBU Paveway Guided Bomb | $22,000[77] |

## Paradox of Precision Guided Munitions

While the ability to strike targets at long range with incredible precision and minimal collateral damage is a remarkable capability for the United States military, the excessive costs of producing and operating the weapon systems and expending these munitions are borderline prohibitive and call into question the economic viability of using these types of ordnance in sustained combat operations or for engagement with certain target sets. For example, a "dumb" HE shell costs 2% of that of an Excaliber PGM round; or put

another way, 42 M795 shells can be purchased for the cost of one Excaliber PGM. Evidence of concerns related to this have already been seen in Iraq when authorization was required at the Army Brigade Commander level in order to fire the Excaliber PGM.[78] With the precedent being set of senior commanders needing to be consulted before high cost ordnance is utilized, the question must be considered if future operational planning will factor into some type of decision-making sequence or target matrix to determine what type of enemy targets merit the use of high-priced PGMs? If so this further adds to the complexities and challenges of combatant commanders when justification must be provided for weapons system employment due to cost concerns.

It can be argued that PGMs require less expended rounds to have needed effects on target as demonstrated in 2003, when Coalition Air Forces in OIF used an average of 1.5 PGMS per target; a ratio far lower than the vast number of munitions needed to destroy or neutralize targets in previous conflicts such as during the Vietnam War when 30 fighter sorties and 176 unguided bombs were needed on average to destroy one target.[79] However, the PGM per target ratio argument is somewhat muted when considering how the expense of PGMs on the Pentagon's budget was clearly felt when a planned purchase of 30,388 Excaliber rounds in 2010 was reduced to only 7058 rounds reportedly based upon high costs.[80] As a comparison, in March 2012 the procurement of the PKM fuze at a much cheaper cost per unit of under $3000 was planned for 23,000 – 25,000 units.[81] While PGMs are, and will continue to be, a critical munition in the U.S. Armed Forces inventory for artillery and other fire support platforms, PKMs provide a more affordable alternative.

## Relevance of Tube Artillery

The rapid evolution of weapons related technology has significantly improved the capabilities of both air and ground based fire support weapon platforms. While these improvements have led to dramatic improvements in accuracy and range, tube artillery's all-weather ability to fix and suppress targets, as well as shape the battlefield through concentrated and massed fires is unrivaled, relative to other fire support platforms. However, in order to retain it's relevance on the battlefields of the future and ensure its continued place in the inventory of the U.S. military as a viable fire support platform, tube artillery must continue to improve its technology and employment capabilities, particularly in the areas of mobility, survivability, responsiveness, range, and accuracy.

The mobility of tube artillery will grow increasingly important in order for it to keep up with armor and mechanized infantry units on the move conducting offensive operations, and perhaps most importantly, survive counter-battery fire and enemy air strikes. Both the M777 and the M109A6 howitzers each have strengths and weaknesses relative to their mobility and the type of terrain they are best suited for. The M777s are at a disadvantage with the constraints of where terrain will permit its prime mover to travel and are also highly vulnerable to enemy air due to longer emplacement and displacement times. Alternatively, the ability to transport towed howitzers via rotary aircraft for remote employment i a significant tactical advantage over self-propelled howitzers. M109A6 howitzers are fully capable of maintaining travel speeds of mechanized forces while being better suited to operating in open terrain but are very heavy and leave a large footprint. While an M777 requires just over two minutes for emplacement and displacement, the M109A6 needs less than a minute.[82] While the

emplacement/displacement times for each of these howitzers are dramatic improvements from years past, the radar and UAV capabilities of adversaries dictates that these times need to be reduced to 30-45 seconds for future survivability.[83]

Weapon system ranging capability continues to be perhaps the biggest shortcoming of the 155 mm howitzers in the U.S. inventory. With a maximum range of 30 km for a RAP round and 40 km for a PGM, U.S howitzers are significantly outranged by 23 foreign militaries around the world.[84] However, ongoing R&D with the M777ER project seeks to lengthen the barrel length of the M777 howitzer therefore increasing range out to 69 km. [85] This improvement will come with an addition of 1000 pounds to the unit's weight and cost approximately $700,000 for the conversion kits. [86] While there has been no commitment by the Army or Marine Corps to purchase this conversion kit, the continued progress of this project and other related technology is critically important to keeping U.S howitzers effective and survivable on the battlefields of tomorrow.

One of the strengths of tube artillery has traditionally been its timely response to calls for fire in all-weather conditions. The ability to put suppressive fires on opposing forces in danger of over running a friendly position, or of being able to quickly dial up a pre-planned target group to disrupt a pending attack has played into the strength of tube artillery in past conflicts and can continue to in the future. Tube artillery's all-weather capability is a distinct and significant advantage that it has over air platforms and is an important consideration for its future relevance. In spite of ever-evolving technology for stealth, navigation, and weaponry, poor weather remains a significant constraint for air platforms. Additionally, unless air assets happen to be on station or in the area, response time can lag which can lead to adverse developments for troops on the ground. No

matter how precision guidance ordnance is, it is only effective if delivered in a timely fashion pursuant to requests from ground units. Thus, tube artillery is currently, and will continue to be the best fire support asset for timely responsive fires.

Aside from the introduction of PGMs and other improved technology, other employment aspects of tube artillery that highlights its relevance is the superior ability to mass fires and re-engage targets. Additionally, the capability to shape the battlefield and attrit enemy maneuver forces are difficult to replicate with air assets and lends further weight to the need to maintain tube artillery in the U.S. inventory.

While the spectrum of missions that the United States military needs to be prepared to support dictates roles for both towed and self-propelled systems, the optimal howitzer of the future should seek to blend aspects of both weapon systems in order to maximize mobility and range. A configuration of a lighter weight, self-propelled howitzer on a wheeled platform, with a .52 caliber tube, capable of emplacing in 30-45 seconds, firing 6-10 shells, then displacing in under a minute would be an optimal future howitzer platform.[87] While there are ongoing efforts in the world of science and technology to look at improving artillery, neither the Army nor the Marine Corps are currently sponsoring R&D into new artillery platforms. Additionally, at the present time the Army plans for the M019A7 Paladin to be its primary cannon artillery howitzer for the next 50 years.[88] To remain relevant on the battlefield of the future, DOD research and development funds must be allocated now to further improve the howitzers currently in the inventory as well as develop new and improved platforms.

## Conclusion

The devastating effects of tube artillery on the battlefield has served as the deciding factor in countless battles throughout history. All-weather responsiveness, the ability to mass and concentration of fires to shape battles, and the shock effect on targeted troops are all reasons that tube artillery has been the first option for maneuver commanders when a battle hung in the balance or suppression of enemy forces was needed. However, advances in weaponry technology and the advent of numerous other fire support platforms has called into question tube artillery's future viability in the U.S. military. To remain relevant and combat effective on the battlefield, tube artillery must continue to evolve while improving it's mobility, responsiveness, accuracy, and range. Regardless, the ultimate test for tube artillery in future conflicts will be whether maneuver commanders have the confidence to call it in as a primary fire support option when troops are in contact and lives are on the line. As the United States faces hard, budget-driven decisions on how to structure the force of the future, the question is not whether the United States military needs the devastating fire support that tube artillery provides, but whether the U.S. can afford to not have this cost effective weapons platform in it's inventory.

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